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DEVELOPMENT OF TEMPERATURE REGULATION IN NESTLING

COMMON SWALLOWS *HIRUNDO RUSTICA*

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During the 1972 breeding season, from March to June, we studied the development of thermoregulation in nestlings of the Common Swallow *Hirundo rustica** Linnaeus. The breeding colony was located at the College of Education, Baghdad, Iraq (Al-Rawy & George 1966). The nests were attached to walls near the ceiling and on flanges of iron girders in corridors of the ground and first floors. The birds found their way to the closed corridors through the windows at staircase and ventilations that were kept open.

The earlier work on the temperature of the Swallow nestlings (*H. r. erythrogaster*) is that of Stoner (1935), who gives the temperature of 1, 5, 10, and 15-day old nestlings. Our aim was to have a more detailed study on the development of temperature regulation by taking nestling temperatures daily from beginning to end of nestling period, making continuous temperature recording of some nestling of selected stages, and by conducting some cold chamber experiments. The results of these investigations are analysed in this paper.

* The nominate subspecies *rustica* is recorded as the breeding population of Iraq (Vaurie 1959).

MATERIALS AND METHODS

A total of 38 **H. rustica** nestlings were used, of which 27 came from eight early brood nests and 11 from three late brood nests. The early nests constituted first broods while the late nests could have been second broods. From May 25 onwards the three late nests were the only active ones in the breeding colony.

Nest contents were under daily check towards the end of incubation period. The nestlings were individually marked by tying a colour thread around a leg at the time of hatching, and, later at about 14th day, by ringing them with numbered Iraq Natural History Museum rings.

The hatching spread (between the first and last hatching) was within 48 hours. Nestlings were aged from the day that hatching began irrespective of their exact hatching time.

Nestlings were taken from the nest, one at a time, in a cardboard box (slightly bigger than the nest) containing cotton in the bottom and carried immediately to a three-sided covered work-room with rather still air. The longest distance from the nest to the working area was about 30 m, but most of the nests were within 8 m. All possible precautions were taken to ensure that the nestlings were not disturbed. The first data taken were the temperature of the nestlings. Inserting the left hand into the box, the nestling was caught from the back, a slow turn of the hand placed the nestling in a slanting semi upside down position, the sensor was quickly introduced into the cloaca to a depth of 12 to 15 mm, and the temperature read. The sensitive part of the sensor has a length of 10 mm, a diameter of 2 mm, and a response time of about four seconds. Less than half a minute after removal of the nestling from the box was sufficient to complete the recording of the temperature. The measurements were taken daily between 16:00 and 18:00 except for two late brood nests, for which from the 10th day onwards they were made between 09:00 and 10:00.

The temperature measuring unit used was the Tastomed Script B manufactured by the Braun Electronic Company (now Deutsche Gulton). Their standard probe M and skin probe HZ were used for

taking the cloacal temperatures and recording of skin temperatures respectively. The accuracy of the temperature indicator was $\pm 0.15^{\circ}\text{C}$ and that of the temperature recorder, $\pm 0.25^{\circ}\text{C}$. By fixing a maximum and minimum self-registering thermometer at the level of the nest and about 1.5 m away, the environmental temperature was measured.

RESULTS

ENVIRONMENTAL TEMPERATURE

The mean of the maximum and minimum temperatures recorded around the nest for the early brood was approximately 25°C (range: maximum 24-31, minimum 20-25, mean 22-28) and for the late brood $33\text{-}34^{\circ}\text{C}$ (range: maximum 33-38, minimum 28-34, mean 31-36). The daily fluctuations was mostly $4\text{-}5^{\circ}\text{C}$, with a maximum of 8° and minimum of 2°C . The ambient temperature of the working area, where the temperature of the nestlings was taken, was generally higher by $1\text{-}2^{\circ}\text{C}$.

NESTLING TEMPERATURES

The approximate mean body temperature of five nestlings in an early brood was continuously recorded for four days after the start of hatching by inserting the sensor (standard probe) through the nest from below so that it was in close contact with the birds. The nestlings maintained a body temperature varying between 35° and 39.5°C , mostly around 38°C . The cloacal temperature of both early and late brood nestlings was taken from the 4th day until they left the nest (Fig. 1).

Udvary (1953) gives the mean minimum (standard) proventriculus temperature of adult *H. rustica* in the post absorptive resting state as 40.45°C (range 40.72-40.06). Although some nestlings of the early brood attained a temperature of 40.0°C by the 8th day, on the average this temperature was not reached until the 10th day. In late broods, some individual nestlings reached this temperature by the 5th day, and the mean for all nestlings on the next day was 40.4°C . No bird had a temperature below 40.0°C beginning with the 14th day in early broods and with the 7th day in late broods.

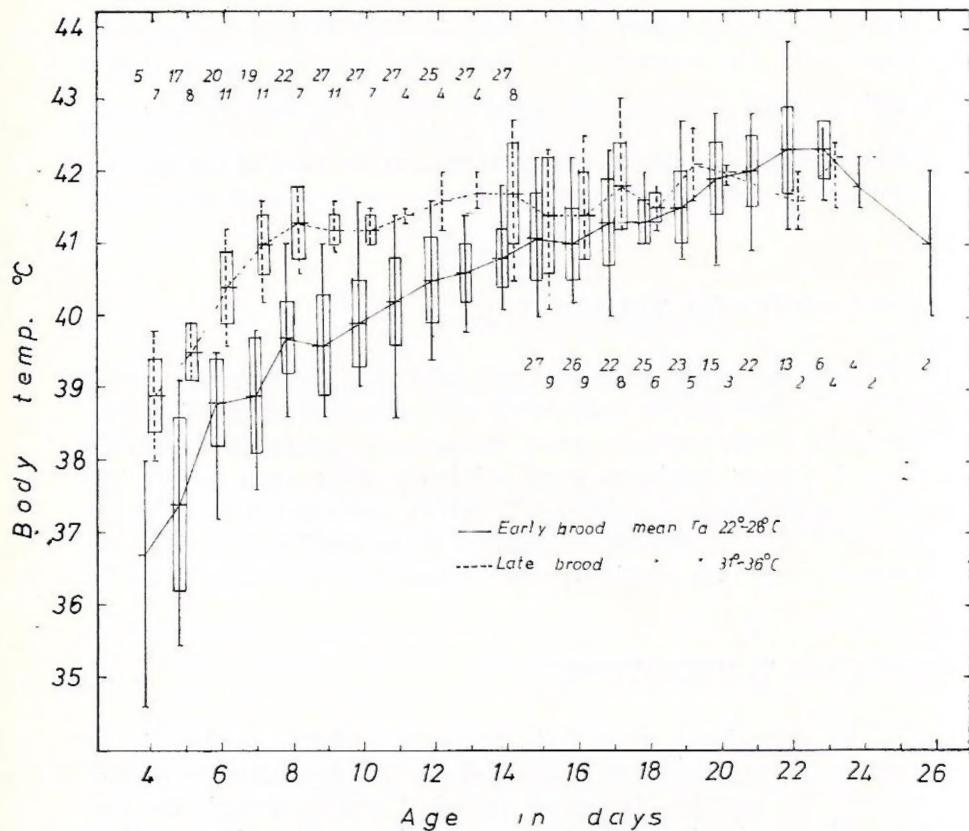


Fig. 1. The deep body (cloacal) temperature of nestlings. Ta = air temperature around the nests ; vertical lines = ranges ; rectangles = + standard deviation ; horizontal lines = mean; upper and lower numbers denote the sample size of early and late broods respectively.

From the 4th to 14th day the temperature of the early and late brood nestlings of the same age were different. The latter, exposed to a higher ambient temperature, Ta, had an average body temperature 1.5°C higher (range 2.2-0.9) than the former. On the 15th day, the difference between the two broods decreased suddenly and for the period to the 19th day averaged 0.4°C (range 0.6-0.2).

The average temperature of nestlings (*H. r. erythrogaster*) given

by Stoner (1935) (1-day-old : 36.4°C, 5-day-old : 39.8°C, 10-day-old: 40.9°C, 17-day-old : 42.2°C) come within our range for the early brood but differ by being higher than the average obtained by us . He gives the average of 19 air temperatures close to the nest taken at the time of nest examination as 24.9°C (range 21.1-29.7), which is in the range of our early brood nest Ta. The difference in results may be attributable to the methods used ; Stoner obtained interthorasic temperature using a non-self-registering mercury thermometer.

COLD CHAMBER EXPERIMENTS

In order to get an insight into the development of temperature regulation some cold chamber experiments and continuous temperature recording of nestlings of selected ages were conducted. All nestlings utilized for the study came from the early brood nests.

A rectangular glass jar ($20 \times 15 \times 10\text{cm}$) , surrounded by ice and placed in a basin, formed the cold chamber which provided a temperature of 10.0°C. After noting the initial temperature of the nestling taken from the nest, it was placed on cotton in the bottom of the jar for a specified time and its temperature again measured (Table 1).

Nestlings, 2 to 4 days old, lost body temperature rapidly even at a moderate Ta, and behaved like poikilothermic organisms. The 7-day old bird was better in resisting a loss of temperature and further improvement was shown by the 9 to 14-day old nestlings. Essentially full control of body temperature regulation was established in nestlings 15 to 18 days old.

CONTINUOUS RECORDING OF NESTLING TEMPERATURE

A circular skin probe, having a diameter of 7 mm, a thickness of 4 mm and weighing one gram, was used for continuous recording of two 8-day old and one 13-day old nestlings. The probe was fixed externally to the breast muscle with adhesive plaster. The nestlings were kept alone during recording in a small open cardboard box in a quiet room, where the change in outdoor light was discernible. Soon after the start and again towards the end of the recording, the cloacal temperature, taken with the standard probe, was found to be nearly identical with the skin temperature.

Table I. Results of cold chamber experiments conducted on nestlings of various ages (temperature in °C).

Age (day)	Ta	Time (min.)	Initial	Temperature End	Loss
02	27.5	10	37.8	30.2	7.6
04	27.5	10	38.0	30.4	7.6
07	10.0	07	39.3	34.8	4.5
09	10.0	15	39.3	36.0	3.3
10	10.0	12	40.1	36.2	3.9
13	10.0	12	40.0	36.5	3.5
13	10.0	10	40.1	36.4	3.7
14	10.0	14	40.8	37.0	3.8
15	10.0	15	41.3	40.0	1.3
16	10.0	15	40.9	39.8	1.1
17	10.0	10	41.4	40.8	0.6
17	10.0	10	41.5	41.4	0.1
18	10.0	23	41.2	40.4	0.8
18	10.0	10	42.0	41.6	0.4

8-day old nestling

Nestling A, having a cloacal temperature of 39.7°C at 16:20, was collected from the nest at 20:00 and recording of its temperature was begun at 23:00. Nestling B, having a cloacal temperature of 39.8°C at 16:30, was collected at 17:00 and recording was commenced at 18:00. Both the 8-day old nestlings maintained a body temperature of $38\text{--}39^{\circ}\text{C}$ until 05:00 in the morning. Thereafter the temperature dropped slowly and steadily by about 2°C to the close of the experiment at 07:00 (Fig. 2).

13-day old nestling

This nestling had a cloacal temperature of 39.8°C when collected from the nest at 17:00. Recording began at 19:00. Its temperature was maintained between 39.5° and 39.0°C until 01:00, then dropped to its lowest level of 38.8°C at 03:00, after which it rose to 39.8°C at 05:00, when the experiment was concluded (Fig. 2).

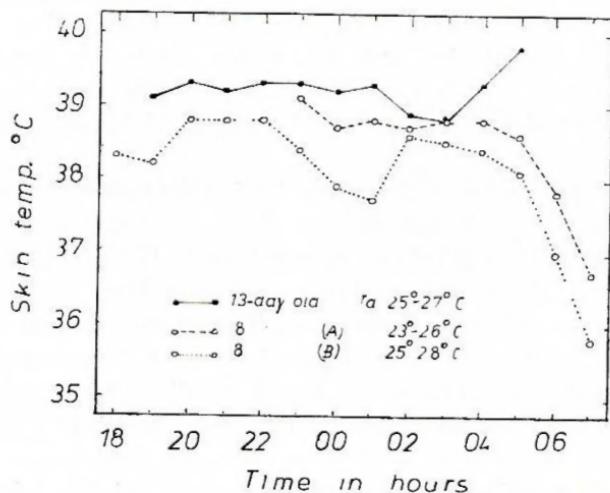


Fig. 2. Overnight skin temperature (average of maximum and minimum each hour) of nestlings, kept alone in an open box, as shown by continuous recording.

DISCUSSION

The feather covering of an 8-day old nestling, with the body contour feathers just beginning to come out of the follicles and the

wing and tail feathers still in their intact sheaths, does not provide good insulation for preventing heat loss from the body (Fig. 3). Maintenance of a high body temperature at this age depends primarily on muscular thermogenesis. This chemical heat production may be a great drain on the energy resources of the nestling. Perhaps the exhaustion of these energy resources accounts for the fall in body temperature in the experiments that is shown to occur towards morning. In nature, this fall does not occur as the nestlings are in close contact with each other, they are protected underneath and on the sides by the fine insulative lining of the nest, and they are provided with heat from the brooding adult.

When the adult swallow settles on the nest for the night, there is a lowering of its body temperature to a level between 40.0° and 39.5°C , which is maintained for some time, but it finally reaches 38.8°C at around 03:00. It then slowly rises to its daytime level $40\text{--}41^{\circ}\text{C}$ by morning (unpublished observation). The 13-day old nestling exhibits a night time fluctuation similar to that of the adult. At this age the body is moderately well insulated with feathers and has attained its maximum body weight (Stoner 1935, George & Al-Rawy 1970).

In spite of the 14-day old nestling having far better feather insulation than the 9-day old bird, the loss in body temperature at both ages, as shown by the cold chamber experiments (Table 1), was more or less the same. However, from the 15th day on, there was a marked decline in the loss of body temperature. This change around the 15th day may indicate the climax in the attainment of thermoregulation, as it is also at this age that early brood nestlings first have body temperature comparable with those of late brood nestlings (Fig. 1). A t-test analysis shows that the difference in mean temperature of early and late brood nestlings of the same age are highly significant ($P < 0.01$ to < 0.001) from the 4th through the 14th days but not at later ages. Night brooding by the adult is generally discontinued by the 14th day (Brown 1924).

There is no significant difference between the body temperature of nestlings 15 and 14 days old in the early broods, but there is a highly significant difference ($P < 0.001$) between the 15th day and ages 4 to 13 days. In late broods, there is no significant difference in nestling

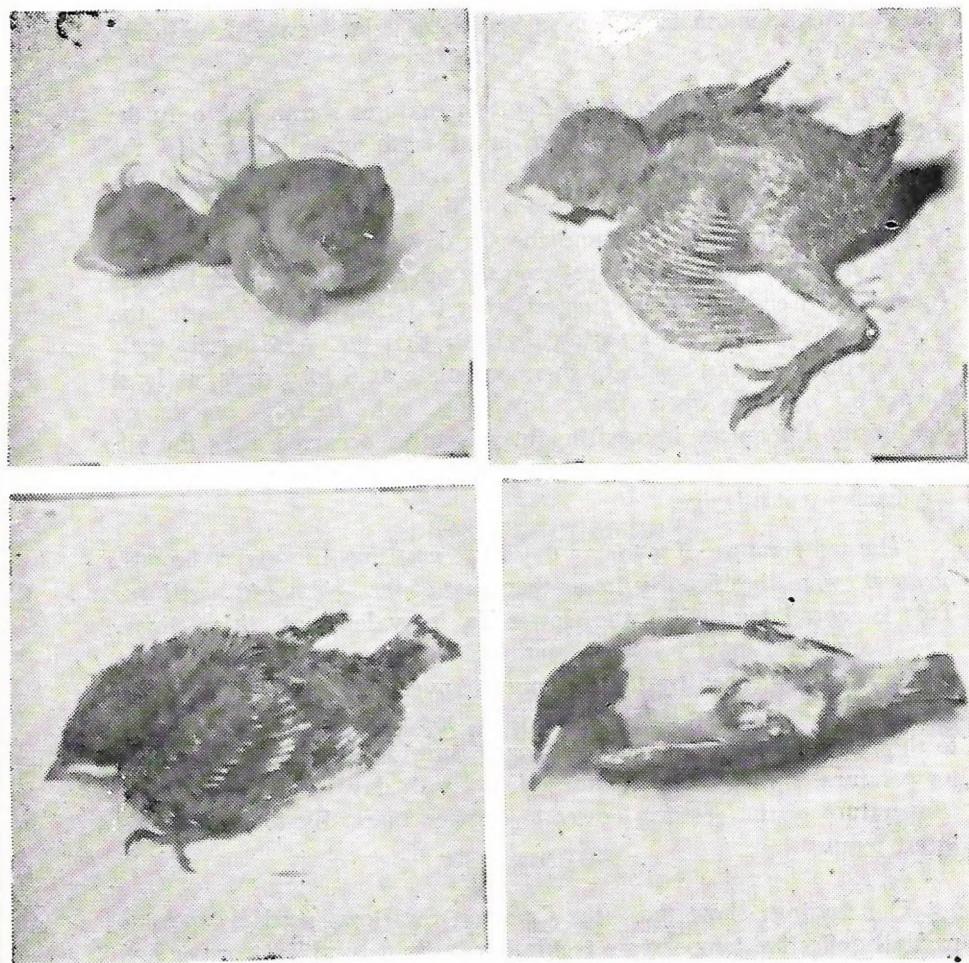


Fig. 3. Nestlings at different stages of development: (upper left) recently hatched; (upper right) 8-day-old; (lower left) 13-day-old : (lower right) 18-day-old, ready to leave the nest in another two days.

temperatures from 7th to 14th days, but there is between 15th and days 4 through 6.

A comparison of consecutive day temperatures shows that only the differences between the 5th and 6th and the 7th and 8th days for the early broods are significant ($P < 0.001$) and between the 5th and 6th and the 6th and 7th for the late broods. This is suggestive that ontogeny of thermoregulation starts around the 5th day. Purchon (1948) records that daytime brooding ceases between the 6th and 9th days, and Davis (quoted by Kendeigh 1956) suggests that it is less prevalent after the first four days. These observations indicate that the nestlings in their nest environment can begin to thermoregulate at 6 to 9 days, at least during the daytime when they are being fed. In late broods, no significant differences in nestling temperatures occurred after the 7th day which shows that 7-day old birds have an effective thermoregulatory capacity at this age.

The temperature of 4 to 13-day old nestlings in early broods, however, were significantly lower than that of the 15-day old nestlings. This is correlated with the lower T_a prevalent at this time. The regulatory capacity was beginning to become effective by the 8th day, as evidenced by the continuous overnight recording of the nestlings, but was not sufficient to bring the nestling temperatures up to the level of the adults. Stoner (1935) surmised the establishment of temperature control at about the 9th to 10th day "when the body temperature of the nestling ceases to respond markedly to fluctuations in air temperature."

Our findings show that the Common Swallow nestling attains partially effective temperature regulation in its natural T_a more or less at the same age 7-8 days as is noted for the Field, Chipping, and Vesper Sparrows, *Spizella pusilla*, *S. passerina*, and *Pooecetes g. grammicus* (Dawson & Evans 1957, 1960) although the former has a nestling period twice that of the above sparrows.

SUMMARY

Hirundo rustica nestlings, 1 to 4 days old, are essentially poikilothermic. However, they are maintained in a virtually homioiothermic condition by parental brooding, a relatively stable microclimate surrounding the nest, and the insulative properties of the nest itself.

Isolated 8-day old nestlings are able to maintain their body temperature at 38° - 39°C for overnight periods in a moderate Ta of 23° - 28°C . Isolated 13-day old nestling has the same capacity as adults for maintaining overnight body temperature.

Early brood nestlings reared at a Ta of 22° - 28°C attained the adult body temperature of 40.0°C on the 10th day. Late brood nestlings raised at a higher Ta of 31° - 36°C reached the adult level on the 6th day.

The temperature of nestlings of the same age in early and late broods were significantly different from the 4th to 14th days but not from the 15th day on. The ontogeny of thermoregulation begins around the 5th day, becomes partially effective by the 7th day, and is fully attained around the 15th day.

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الخلاصة

Hirundo rustica مراحل التنظيم الحراري في صغار السنونو (سندي وهندي) وهو من ملازمات العش :- يوصف كالتالي :

التنكيف او التحسن الحراري يبدأ في اليوم الخامس تقريباً ويصبح ذو تأثير جزئي في اليوم السابع . ثم يصل فاعليته العظمى في اليوم الخامس عشر تقريباً .